it would not attempt to define the conditions of eligibility for membership, but that invitations to join in the formal organization of the association should be sent to persons of full professorial rank whose names appeared on the lists of distinguished specialists prepared for the committee in each of the principal subjects, provided that such professors were connected with institutions having five or more names upon these lists. Some 650 of those to whom these invitations were sent have thus far expressed their sympathy with the general purposes formulated in the circular of the committee on organization, and their purpose to adhere to the association.

In accordance with the action above reported, members of the university teaching profession who did not receive invitations to the New York meeting, and who desire to become members of the Association, are asked to signify that desire to any of their colleagues who are already charter members or who may become such during the period allowed for that purpose—the first three months of the present year.

A. O. Lovejoy,
Secretary

Johns Hopkins University

The American Association for the Advancement of Science

Safety Engineering[1]

The address which forms part of the duty each year of your successive chairmen might have for its unvarying subject the newest subdivision of the engineer's field, since each year seems to furnish a new title to our lengthening list of engineering specialists.

One of the late differentiations calls attention to the field of safety engineering, and I bring to your attention some phases of this work. This portion of the field of engineering can not be said to involve any radically new fact or discovery, but to be rather a new grouping of interests as a result of a change of accent among the many industrial factors. In developing any engineering design there is usually a compromise between prime factors which dominate the result and minor factors which receive less accent; so also in industrial life such prime factors as production, cost, profits, expansion, etc., have heretofore received the greater accent, while the item of safety of the employee and the public, which has always been a factor in design and in management, has oftentimes been given relatively small weight. There is a rapidly growing feeling that every industry should receive its workers each day in fit condition and should return them to their homes whole and in like fit condition. Strong accent is now being given to this idea, which has resulted in a movement of very considerable momentum, and this change in accent is finding its expression in various legislation, in workmen's compensation acts, in the whole safety movement, including the work of safety engineering. Safety engineering has for its object the elimination of industrial accidents. While the result of such an accident was borne largely by the injured individual, the prevention of accidents remained more or less of a minor factor in industrial problems, but as the industry is required to carry directly a larger share of the burden resulting from accident, the problem has become one of prime importance. Each engineer, mechanical, electrical, civil and mining, is now asked to view his work from a new angle. Guards, guides and protective devices are added where it was perfectly evident these devices should have been before, but it be-

[1] Address of the vice-president and chairman of Section D of the American Association for the Advancement of Science, Philadelphia, December 31, 1914.

comes equally evident that this is a most superficial and inadequate treatment of a subject of large proportions. Statistical information is needed as to the kind of injury and the success of preventive methods. Questions arise as to the bearing on the accident problem of nationality, general intelligence, age, temperance, fatigue, housing, lighting and a multiplicity of factors usually considered as outside of the field surveyed by the engineer. The purely engineering phase of this problem has been variously estimated as forming only 10 to 25 per cent. of the whole, the problem being more largely one of mental attitude toward the thought of safety on the part of the employee and the whole organization, but the engineer's point of view seems particularly favorable as a point of departure for exploring the whole field and reducing observations to concrete changes in equipment and management. This situation has produced the safety engineer. His work is a new grouping of studies and interests. Beside his purely engineering training he is brought close to the doctor, the chemist, the social worker, the statistician, the works diplomat, the psychologist, the labor organization, legislative limitations and the lawyer. He can no longer measure all his work directly in dollars and he looks first to a column of statistics for evidence of his profits.

In the large industrial organizations the best engineers are thus engaged, under the immediate observation of the administrative head. The excellent results which have been obtained in the reduction of accidents accounts for the enthusiasm shown by industrial safety workers and organizations.

Much of this work requires only special attention to the idea of safety as an important matter, time, patience, careful observation, and the application of obvious remedies which are already in use. The great need at this point is for standardization of method. Considerable sums are expended for protective devices and constructions which are more or less inadequate and which have to be replaced as the art develops. In fire protection and electric installation, it has been found necessary to standardize equipment and a similar need is to be met in safety methods and devices. This can be brought about by preparing standard detailed specifications covering each case or by requiring the use of approved devices, the approval to be issued by some investigative body provided for the purpose. Detailed specifications are apt to be confusing and cumbersome and lack the simplicity of an approval system. The approval of safe devices must, however, be done by some body whose decisions will command general support as being the result of careful investigation.

In the mineral industries where the government has provided an investigative bureau for the specific purpose of "increasing safety," the method of granting approval to safe devices after careful investigation is already in operation and has so far provided a list of permissible explosives, approved miners' electric lamps, explosion-proof electric motors, switches, etc. Such work must of necessity move slowly, for careful investigation requires both time and money. For the general industrial field other interests are preparing to provide a means of standardizing similar to that brought about by the underwriters' fire insurance regulations.

Much of the more obvious preventative measures can be recognized by members of any and every organization, but there is a class of investigation the need of which has become quite evident which can not be expected of the usual industrial organization. Unsafe conditions are sometimes the result

of obscure physical facts, not so readily apparent, and these cases require long and careful scientific investigation with adequate laboratory facilities. An excellent illustration of this is found in the hazard of coal-mine explosions. Such a subject is one studied with difficulty by a single industrial organization and must be referred to some agency specially equipped for investigative work involving engineering, chemistry, physics and a very considerable expenditure of funds. The mining industry presents many such problems, such as the ignition of gases and various coal dusts by explosives, by electric sparks, and static discharges, and by filaments of broken electric lamps. The permissible limits of vitiation of mine air by natural gases, oxidization of timbers, dusts and fumes and by the use of internal combustion engines for haulage; these require extensive physiological as well as field and laboratory investigation. The deterioration of vital parts of equipment by fatigue, shock and corrosion demands laboratory investigation to devise means for proper protection and inspection.

Every industry will present similar safety problems that must be studied more carefully than can be expected of the unaided industrial organization. It is this phase of safety engineering that I wish to specially emphasize.

There are several agencies that can be expected to meet in various degree this need. One of the most promising is that of cooperation between a group of members of an industry and established laboratories, federal, state or educational, which laboratories may be specially fitted by men and equipment for investigating the special problem in hand. By this method the industry furnishes funds for the work while the laboratories furnish oversight, direction and experience in similar investigations. An investigation of the causes of explosion of grain dust by a group of millers and men interested in coal-dust explosions from the Federal Bureau of Mines illustrates this method. Such cooperation between industrial organizations and investigative agencies in safety problems should be greatly extended.

Investigative work in engineering laboratories connected with educational institutions have confined their attention largely to questions of efficiency. The present increased accent on problems of safety should find a similar accent in college engineering courses. Courses in engineering design and construction could without change in hours or relative weight in the whole course give increased emphasis to questions of safety by a careful selection of illustrative problems. Many organizations require that every drawing be "checked for safety" so that each construction has been criticized from this point of view and made to conform to safety standards. The standard screw and nut which has demanded the attention of generations of budding engineers in courses in drawing and design should find a worthy running mate in the standard safety hook or guard railing or belt protection. This change of emphasis should follow also into the engineering laboratories. As an illustration, it is essential for safety that gasoline locomotives used in mines or any enclosed space shall produce exhaust gases as free from carbon monoxide as possible. The size of machine that can safely be used under any given mine condition is a function of this carbon monoxide output, and a study of the performance in this regard is of quite as much importance as a study of the capacity or economy of the engine.

State engineering experiment stations in those states which have established such institutions can also be expected to take an

increasing interest in investigations of safety problems peculiar to the industries of each state. Their function has been to investigate fundamental problems relating to the efficient use of the material resources of the state, but the change of emphasis brought about by the safety movement will make safety problems of equal moment.

Another agency for the organized study of safety problems is found in the banded casualty insurance companies, who are in a peculiarly favorable position to bring an economic pressure to bear upon the industries to install standard, adequate safety devices. They propose to offer a reduction in rates where approved safety devices are installed and the underwriters' laboratories are hereafter to test approved safety devices to reduce accident risks as well as devices for reducing fire risks.

The general government is also aiding in safety engineering, as it is the province and duty of the Federal Bureau of Mines to conduct investigations with a view to increasing safety in the mining, quarrying, metallurgical and other mineral industries. This is the first government bureau to be established with the specific object of studying industrial safety in fields other than transportation. The laboratory facilities include an equipped coal mine for the study of mine explosions, chemical and physical laboratories, and the new buildings about to be commenced include mechanical and electrical laboratories.

These numerous agencies for the careful study of safety problems, which lie just behind the field of the self-evident and in the land of the more or less obscure, will each contribute something to the motley interests of the safety engineer and will help to eliminate industrial accidents.

O. P. HOOD

U. S. BUREAU OF MINES

ISOSTASY AND RADIOACTIVITY[1]

IT is the purpose of this paper to point out some apparent discrepancies between the observations of geodesists on isostasy and the inferences which some radiologists have drawn as to the great age of certain specimens of minerals. It seems well to begin by reviewing the results of isostatic investigations in order to estimate the degree of confidence to which they are entitled; and recent advances in radiology demand similar attention.

Correlation of these widely distinct researches is possible because it happens that the emission of heat by a globe whose excess temperature is due solely to radioactivity obeys Fourier's law exactly as does that emitted by a hot but radioinactive globe.

Geology as a science is conditioned by the state of the earth's interior, and our knowledge of its constitution is now advancing. So late as the foundation of this society in 1889 the Cartesian doctrine of a fluid earth enclosed in a very rigid shell a score or two of miles in thickness was held by most geologists. We now know that the globe is solid and on the whole of great rigidity and probably divisible into at least four distinct shells each more rigid than that overlying it, that the irregularities in density and structure which are so marked at the surface extend only to a depth of something like a fiftieth of the earth's radius; that open cavities or cracks may exist at depths of 20 miles and very possibly down to the level of isostatic compensation. We know too that the earth is radioactive but that the radioactivity is superficial, reaching only to a moderate though uncertain level; we also know, however, that the earth's heat is not wholly

[1] Abstract of the presidential address before the Geological Society of America, December, 1914. The full paper is too long for oral delivery and only this abstract was read at the meeting.